

ElectroAcoustics and Bells

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Electro-Acoustics and Bells

IF we look back on the story of Arts and Sciences we notice a discontinuity between the progress of these activities of mankind. Progress in one of these fields is usually accompanied by a condition of idleness in other fields.

The progress of Art particularly is most apparent in times when artistic stimulus is lacking. We notice, for example, that the deepest kind of music is composed by people who for some reason lack the opportunity of hearing organized sound.

One of the fields which Science and Art recently shared is that of electro-acoustics. By such we mean the field of the many applications of electricity for conveying or reenforcing sounds.

The creation of radio, talking pictures and similar devices at first caused definite economic hardships for some artists. Later, however, they became a tremendous source of revenue for them and at the same time emphasized the differences between various forms of skill and ability to the advantage of the best among them.

The activity and possibilities of the artist have unquestionably much improved.

Attempts have been made toward the scientific improvement of musical instruments. Most musical instruments as they exist today, being the offspring of a natural selection extending through many centuries, have resisted undue attack. Some instruments have also been created, based entirely upon new electric devices. They are the products of engineering imagination and have not as yet attained the artistic heights held by classical instruments.

One of the many examples in which Electro-acoustics and Art have come in contact, and one in which Science has undoubtedly been a help to Art, is that of bell carillons.

Bells represent a peculiar case. They are a very old instrument and have been improved for centuries. They have, however, never been considered entirely worthy of the name "musical instruments" by critical musicians. No famous composer has written music of note for bells, and

bell players have been compelled to transcribe and adapt music written for other instruments. The music thus arranged very often retains but little of its original significance.

In spite of these facts bell carillons have continued to spread all over the world. This is probably due to the fact that they are the only powerful out-of-door instrument existing, and they can be played by a single person. They give a personality to most small towns and villages and are something solid and permanent not only as an instrument, but as a memorial. Beautiful towers have been erected to house carillons, but most musicians are still dissatisfied with their music.

Since the time of Helmholtz investigations have been made in the attempt to find out the reason for the much discussed unpleasantness of the bell sound, with such crude devices as tuning forks and resonators, which were the only known means for acoustic analysis at that time. Simpson first indicated a system for tuning a bell, and this was rapidly adopted. It includes, however, component tones not in strictly musical succession.

Every elementary musical instrument, as, for example, the string, has a fundamental note, and some harmonics of naturally decreasing intensity.

Every portion of a bell is tuned separately on a particular fundamental note. The bell, therefore, when struck does not emit a fundamental and a series of harmonics, but a number of fundamentals, consisting mainly in a hum note, followed by another fundamental an octave above, by a minor third, a fifth, and another octave, every one of these notes having its natural harmonics.

The tuning is so arranged that the fundamentals of higher pitch are, or rather should be, coincident with the harmonics of the lowest fundamental.

The note which is considered not strictly musical is the third. For some reasons this tone behaves in an elusive way creating musical combinational tones which when too predominant become quite undesired in music. Considerable limitations are thus introduced in the playing.

The knowledge of bells remained at this stage until electrical systems were employed to analyze their sound.

It was then found that in the acoustic spectrum of bells, tones are not single lines but doublets, triplets and sometimes even more elaborate groups. These groups of tones are not found in their theoretical position, but are somewhat shifted about. Tones, moreover, are found which are not meant to be present at all. It is easy to imagine how elaborate the harmonics of this kind of "fine structure" become.

Furthermore, the various tones are built up and go through maximums and in turn decrease each with entirely different laws, with the final result that every bell gives a large number of objectionable sounds and combinational tones as mentioned above.

The reason for the difference between the theoretical tuning and its practical results is most probably to be found in the devices employed by the founders for tuning the bells. For this purpose tuning forks and resonators are used and the thickness of the rough walls of the bell is reduced until the desired note is emitted. The final operation consists in counting the beats between a tuning fork and the tone. It so happens, however, that it is difficult for the tuner to judge whether the tuning fork or the bell is pitched higher. The mechanical requirements of the tuning are such that at times the same note is approached from two different sides and this most probably is the reason for the creation of so many doublets.

A survey made with several musicians on the subject of bells brought up those points which are apparently the origin of artistic dissatisfaction in the bell tones. It was pointed out by artistically minded people that the carillon could actually become a musical instrument if any music could be played on it without the need of too elaborate a transcription.

In physical terms this means that the ideal bell should be one having the same harmonic succession as an elementary musical instrument. The next step in the research, therefore, was taken with the purpose of performing this transformation. This included a total or partial elimination of undesired tones.

In order to perform such elimination, it was necessary to find out in which part of the bell and at what time the objectionable tones were generated. An attempt to correct the spectrum

of existing bells was made with the use of a rubber-covered, metallic frame acting as a damper when pressed against a section of the bell.

The finished dampers are now automatically operated by compressed air and electrically controlled, some time after the bell is struck. The interval of time is adjusted for each bell in such a way as to make the damper action coincident with the beginning of the bell's emission of the third, which is the most important tone to cut off.

The sound of bells so corrected is a great improvement over that of the old type. An installation using such dampers and operating automatically has recently been completed at the Riverside Church Carillon in New York.

Some research was carried on a short time ago in the endeavor to build an instrument as perfect as possible within a reasonable cost, and representing further possibilities of improvement.

The best solution was found to lie in the use of miniature bells of the same shape as large bells tuned in the same way and thus giving sound very similar to the full-sized ones. In the judgment of several musicians these small bells are very pleasing to the ear. Their cost is much reduced because the cost of bells is largely proportional to the amount of metal employed, which amount varies approximately with the cube of the bell's linear dimensions. A set of miniature bells can be acquired for approximately one-twentieth the cost of the equivalent large bells and can be heard quite satisfactorily indoors in any theater, church or hall.

The sound of such bells can be conveniently picked up, amplified and broadcast through loudspeakers at any desired distance, direction and sound level.

Without going into a description of high qual-

ity power audio equipment, since its features are widely and generally known to physicists, there is one point of interest which should be mentioned, that being the pickup of the sound from the bell. It is generally known that there is considerable difficulty in performing a microphone pickup of sounds which vary greatly and suddenly in intensity. Such difficulty in bells is eliminated by a system of direct pickup which has proved quite successful. It consists in fastening to one or more points of the surface of the bell one or more coils placed in a permanent or electro-magnetic field and connected to an amplifier. Since various sections of the bell emit different sounds, the coils can be placed in such a way as to act as a selective pickup and obtain the most pleasant combination of tones, so as best to satisfy the listener.

This same system can be used for pickup and amplification of full-sized bells, thus fully modifying their tones so that they may comply with the tastes of the most exacting audience.

A selective pickup and amplification used as sound reenforcement is another system for correcting tones of existing bells.

Bells are cherished by many people because of their connection with the past. It must be kept in mind that up to the present time they have been steadily improved, and, since they have certainly not as yet reached perfection, there is no reason why their progress should now be stopped. With the help of electricity not only can they be improved artistically, but through more wide-spread use they can reach a larger audience, thus representing for the public another source of musical enjoyment originating in the laboratory.

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